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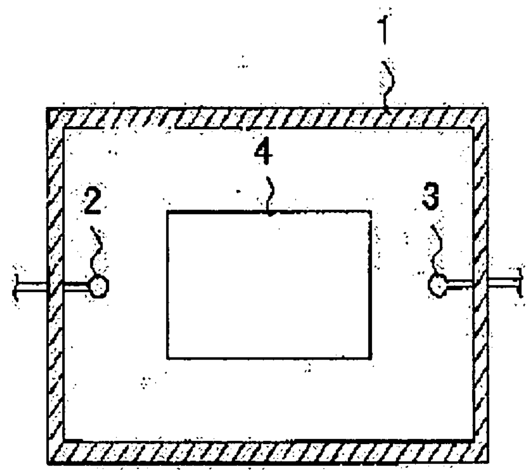
(54) DIELECTRIC CERAMIC, PRODUCTION METHOD THEREFOR, AND DIELECTRIC RESONATOR OBTAINED BY USING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain dielectric ceramic which has high εr, and Q value, and has a small absolute value of temperature coefficient τf for resonance frequency.

SOLUTION: The dielectric ceramic consists of a polycrystal body consisting of oxides containing at least rare earth elements (Ln), Al, M (M is Ca and/or Sr), and Ti as metallic elements, and contains prescribed amounts of Si, Fe and Zr.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the dielectric porcelain used for the various charges of resonator material and the dielectric substrate ingredient for Media Interface Connector (Monolithic IC) which are used in said RF field, the charge of dielectric waveguide material, a laminating mold ceramic condenser, etc., and the dielectric resonator using this in RF fields, such as microwave and a millimeter wave, concerning the dielectric porcelain and dielectric resonator which have high specific-inductive-capacity epsilonr and the acutance-of-image Q value of resonance.
[0002]
[Description of the Prior Art] Dielectric porcelain is widely used for a dielectric resonator, the dielectric substrate for Media Interface Connector, waveguide, etc. in RF fields, such as microwave and a millimeter wave. Since the wavelength of the electromagnetic wave spread in (1) dielectric is shortened to one (1/epsilonr) half as the property demanded The dielectric loss in (2) RF field is [that specific inductive capacity is large to the demand of a miniaturization,] small, That is, it being Q and the change to the temperature of high (3) resonance frequency being small, i.e., the temperature dependence of specific-inductive-capacity epsilonr being small stable, and the above three properties are mainly mentioned.
[0003] As such dielectric porcelain, the dielectric porcelain which consists of a CaO-TiO2-Nb2O5-DO (D is Zn, Mg, Co, Mn, etc.) system is shown in JP,4-118807,A. However, with this dielectric porcelain, the Q value when converting into 1GHz was as low as 1600 to about 25000, and since it was large in degree C and about 215-835 ppm /, temperature coefficient tauf of resonance frequency raised Q value, and the technical problem that tauf was made small occurred.
[0004] Then, these people proposed the dielectric porcelain (referring to JP,6-76633,A and Ln are rare earth elements) of a LnAlCaTi system, the dielectric porcelain (refer to JP,11-278927,A) of a LnAlSrCaTi system, and the dielectric porcelain (refer to JP,11-106255,A) of a LnAlCaSrBaTi system.
[0005]
[Problem(s) to be Solved by the Invention] However, with LnAlCaTi system dielectric porcelain (referring to JP,6-76633,A and Ln are a rare earth element), the technical problem that specific-inductive-capacity epsilonr needed to raise Q value since Q value is 20000-58000 and Q value becomes small in the range of 30-47 depending on [35000] the case occurred.
[0006] Moreover, with the dielectric porcelain (refer to JP,11-278927,A) of a LnAlSrCaTi system, the technical problem that specific-inductive-capacity epsilonr needed to raise Q value since Q value is 20000-75000 and Q value becomes small similarly in the range of 30-48 depending on [35000] the case occurred.
[0007] Furthermore, with the dielectric porcelain (refer to JP,11-106255,A) of a LnAlCaSrBaTi system, the technical problem that specific-inductive-capacity epsilonr needed to raise Q value as for Q value by 31-47 since it is 30000-68000 and Q value becomes small similarly depending on [35000] the case occurred.
[0008] This invention was completed in view of the above-mentioned situation, and especially the purpose is that epsilonr offers [in / in specific-inductive-capacity epsilonr / 40 or more range] the dielectric porcelain and dielectric resonator of specific-inductive-capacity epsilonr small temperature dependence and stable with as high and Q value as [or more] 46000 43000 or more Q value in the range of 30-48.

[0009]
[Means for Solving the Problem] As a metallic element, at least, the oxide containing rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti is consisted of the polycrystalline substance which considers as a principal component, and, as for the dielectric porcelain of this invention, the content of Si, Fe, and Zr is characterized by being 0.001 - 0.8 % of the weight by SiO_2 conversion at 0.001 - 0.02-% of the weight, and ZrO_2 conversion by 0.001 - 0.02-% of the weight, and Fe_2O_3 conversion, respectively.
[0010] Moreover, the dielectric porcelain of this invention is characterized by Si existing in the grain boundary.
[0011] Furthermore, the aforementioned dielectric porcelain contains rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti at least as a metallic element, and is an empirical formula aLn_2O_X-bAl_2O_3 and cMO-$dTiO_2$ (however, 3<=x<=4)
When expressed, a, b, c, and d are characterized by satisfying 0.056 <=a<=0.2140.056 <=b<=0.2140.286 <=c<=0.5000.230<d<0.470 a+b+c+d=1.
[0012] Moreover, it is characterized by containing at least one sort in Mn, W, Nb, and Ta 0.01 to 3% of the weight in total as a metallic element by $2OMnO_2$, WO_3, Nb_2O_5, and Ta5 conversion.
[0013] The content of Si, Fe, and Zr the manufacture approach of the porcelain of the dielectric of this invention by SiO_2 conversion, respectively Moreover, 0.001 - 0.02 % of the weight, the rare earth elements (Ln) contained 0.001 to 0.8% of the weight by 2OFe3 conversion by 0.001 - 0.02-% of the weight, and ZrO_2 conversion -- an oxide -- The process to which cation metal concentration carries out wet grinding of the raw material which consists of at least two or more sorts in aluminum oxide, M (M is calcium and/or Sr) oxide, and Ti oxide using 0.001 or less % of the weight of water, The process which carries out temporary quenching using the bowl which I will make fix and will cook rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M is calcium and/or Sr), and Ti, It is characterized by including the process which reduces Fe and Fe compound which are contained in the raw material fine particles before shaping, and the process which calcinates Si in the gas which is not included substantially.
[0014] Furthermore, the dielectric resonator of this invention arranges the above-mentioned dielectric porcelain between the input/output terminals of a pair, and constitutes the dielectric resonator which operates by electromagnetic-field association.
[0015]
[Function] With the dielectric porcelain of this invention, as a metallic element, at least, it can consist of rare earth elements (Ln) and the polycrystalline substance which uses the oxide containing aluminum, M (M is calcium and/or Sr), and Ti as a principal component, and Q value can be raised by making the content of Si, Fe, and Zr into 0.001 - 0.8 % of the weight by Fe_2O_3 conversion 0.02 or less % of the weight by SiO_2 conversion at 0.001 - 0.02-% of the weight, and ZrO_2 conversion, respectively.
[0016] The content of Si, Fe, and Zr the dielectric porcelain of this invention by SiO_2 conversion, respectively In addition, 0.001 - 0.02 % of the weight, the rare earth elements (Ln) contained 0.001 to 0.8% of the weight by 2OFe3 conversion by 0.001 - 0.02-% of the weight, and ZrO_2 conversion -- an oxide -- The process to which cation metal concentration carries out wet grinding of the raw material which consists of at least two or more sorts in aluminum oxide, M (M is calcium and/or Sr) oxide, and Ti oxide using 0.001 or less % of the weight of water, The process which carries out temporary quenching using the bowl which I will make fix and will cook rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M is calcium and/or Sr), and Ti, By the manufacture approach including the process which reduces Fe and Fe compound which are contained in the raw material fine particles before shaping, and the process which calcinates Si in the gas which is not included substantially The crystal structure of the perovskite mold crystal containing rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti can be considered as regulation-ization, and high Q value can be obtained by this.
[0017]
[Embodiment of the Invention] This invention is explained below.
[0018] The dielectric porcelain in this invention means the thing of the polycrystal sintered compact which fabricates a non-sintered compact, calcinates and is obtained. And in order to make Q value high, as a metallic element, it consists of rare earth elements (Ln) and an oxide containing aluminum, M (M is calcium and/or Sr), and Ti, and it is important that the content of Si, Fe, and Zr is [in SiO_2 conversion] 0.001 - 0.8 % of the weight

at 0.001 - 0.02-% of the weight and Fe_2O_3 conversion in 0.001 - 0.02-% of the weight and ZrO_2 conversion, respectively at least.

[0019] Here, as a metallic element, I hear that each crystal with which said polycrystal is constituted consists of rare earth elements (Ln) and an oxide containing aluminum, M (M is calcium and/or Sr), and Ti, and consisting of rare earth elements (Ln) and the polycrystalline substance which uses the oxide containing aluminum, M (M is calcium and/or Sr), and Ti as a principal component has the dielectric porcelain of this invention at least.

[0020] As for the rare earth element (Ln) contained on the dielectric porcelain of this invention, it is desirable to consist of at least one or more sorts in the oxide of Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, and Yb. In order to make Q value high, as for a rare earth element, it is desirable to consist of at least one or more sorts in La, Nd, Sm, Eu, Gd, and Dy. In order to make Q value high furthermore, especially the thing of a rare earth element consisted of at least one or more sorts in La, Nd, and Sm is desirable. In order to make Q value high in this invention, La is the most desirable among rare earth elements.

[0021] As for the rate of said polycrystal which uses rare earth elements (Ln) and the oxide containing aluminum, M (M is calcium and/or Sr), and Ti as a principal component at least, it is desirable as a metallic element that it is more than 90 volume % among the crystals included in the dielectric porcelain of this invention.

[0022] moreover, the dielectric porcelain of this invention -- as a metallic element -- at least -- rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti -- respectively -- LnO (X+3)/2 (3<=x<=4) and aluminum2 -- it is desirable to contain a total of 85% of the weight or more by O3, MO (for M to be calcium and/or Sr), and TiO_2 conversion.

[0023] It is desirable for the crystal which consists of said principal component to be a perovskite mold crystal which consists of the solid solution of LnAlO (X+3)/2 (3<=x<=4), and $MTiO_3$ (M is calcium and/or Sr), for example, it becomes at least one of $NdAlO_3$, $SmAlO_3$, and $LaAlO_3$ sorts from at least one sort of solid solutions among $CaTiO_3$ and $SrTiO_3$.

[0024] The reason for having limited the content of Si, Fe, and Zr to the above-mentioned range in the dielectric porcelain of this invention, respectively is as follows.

[0025] It is because it is it hard to sinter that it is less than 0.001 % of the weight to contain Si 0.001 to 0.02 or less % of the weight by SiO_2 conversion, and is because Q value will fall by SiO_2 conversion if [than 0.02 % of the weight] more. In order to raise Q value, the upper limit of the amount of Si has 0.01 desirable % of the weight at SiO_2 conversion.

[0026] Fe is contained 0.001 to 0.02% of the weight by 2OFe3 conversion, because it is substantially difficult for Fe 2O3 to carry out to less than 0.001% of the weight, and it is because Q value will fall if there is more Fe 2O3 than 0.02 % of the weight. In order to raise Q value, the upper limit of the amount of Fe(s) has 0.01 desirable % of the weight at 2OFe3 conversion.

[0027] Containing Zr 0.001 to 0.8% of the weight by ZrO_2 conversion because it is difficult for ZrO_2 to obtain dielectric porcelain with it as it is less than 0.001 % of the weight, it is because Q value will fall if there is more ZrO_2 than 0.8 % of the weight. [high and Q value and] [cheap] In order to raise Q value, the upper limit of the amount of Zr has 0.4 desirable % of the weight at ZrO_2 conversion, and the minimum of the amount of Zr has 0.01 desirable % of the weight at ZrO_2 conversion.

[0028] Moreover, as for the dielectric porcelain of this invention, it is desirable that Si exists in the grain boundary. Q value can be raised especially if Si exists in the grain boundary. Said grain boundary means the grain boundary of the crystal which consists of the main crystal phase of the dielectric porcelain of this invention. Especially if Si exists in the grain boundary in the dielectric porcelain of this invention, the reason which can make Q value high will be considered as follows.

[0029] It consists of a perovskite mold crystal into which it mentioned above and with which the main crystal phase of the dielectric porcelain of this invention consists of said solid solution like. For example, it is thought that a defective equation in case Si dissolves to aluminum site included in the perovskite mold crystal which consists of said solid solution is expressed like ** 1.

[0030]

[Formula 1]

$$SiO_2 \xrightarrow{AlO_{\frac{3}{2}}} Si_{Al}^{\cdot} + \frac{3}{2} O_O^X + \frac{1}{4} O_2 + e'$$

[0031] It turns out that Si with a bigger valence than aluminum acts as a donor of n mold, and an electron is emitted from ** 1. The conductivity of dielectric porcelain becomes large by this, and it is thought that Q value falls as a result. When Si dissolves to for example, La site or calcium site, the conductivity of dielectric porcelain becomes large similarly, and it is thought that Q value falls. Since emission of an electron which was mentioned above on the other hand since it was hard to dissolve to other elements when Si exists in the grain boundary does not take place, it is thought that Q value does not fall.
[0032] When Si exists in the grain boundary of the dielectric porcelain of this invention, existence of Si can be checked using the analysis by the transmission electron microscope and the selected-area-electron-diffraction image and energy dispersive X-ray spectrometry (EDS analysis), a minute X-ray diffraction method, etc.
[0033] Furthermore, the dielectric porcelain in this invention contains rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti at least as a metallic element, and is an empirical formula aLn2 OX-bAl2O3 and cMO-dTiO2 (however, 3<=x<=4)
When expressed, it is important that a, b, c, and d satisfy 0.056 <=a<=0.2140.056 <=b<=0.2140.286 <=c<=0.5000.230<d<0.470 a+b+c+d=1.
[0034] In the dielectric porcelain of this invention, the reason which limited the mole ratios a, b, c, and d of each component to the above-mentioned range is as follows.
[0035] That is, in the case of 0.056<=a<=0.214, having been referred to as 0.056<=a<=0.214 has large epsilonr, and its Q value is high, and it is because the absolute value of temperature coefficient tauf of resonance frequency becomes small. As for especially the minimum of a, 0.078 is desirable, and, as for the upper limit of a, 0.1866 is desirable.
[0036] In the case of 0.056<=b<=0.214, having been referred to as 0.056<=b<=0.214 has large epsilonr, and its Q value is high, and it is because the absolute value of tauf becomes small. As for especially the minimum of b, 0.078 is desirable, and, as for the upper limit of b, 0.1866 is desirable.
[0037] In the case of 0.286<=c<=0.500, having been referred to as 0.286<=c<=0.500 has large epsilonr, and its Q value is high, and it is because the absolute value of tauf becomes small. As for especially the minimum of c, 0.330 is desirable, and, as for the upper limit of c, 0.470 is desirable.
[0038] In the case of 0.230< d<0.470, having been referred to as 0.230< d<0.470 has large epsilonr, and its Q value is high, and it is because the absolute value of tauf becomes small. As for especially the minimum of d, 0.340 is desirable, and, as for the upper limit of d, 0.450 is desirable.
[0039] 0.75 <=(b+d)/(a+c)<=1.25 are desirable in order to make Q value high in this invention. In order to make Q value high furthermore, as for especially the minimum of (b+d)/(a+c), 0.85 is desirable, and as for especially the upper limit of (b+d)/(a+c), 1.15 is desirable.
[0040] Furthermore, the dielectric porcelain of this invention contains at least one or more sorts in Mn, W, Nb, and Ta 0.01 to 3% of the weight as a metallic element by 2OMnO2, WO3, Nb 2O5, and Ta5 conversion. It is because Q value will improve remarkably if containing at least one or more sorts in Mn, W, and Ta 0.01 to 3% of the weight by 2OMnO2, WO3, Nb 2O5, and Ta5 conversion contains 0.01 to 3% of the weight. Especially in order to make Q value high, it is desirable to contain at least one sort in Mn, W, Nb, and Ta 0.02 to 2% of the weight by 2OTa5 conversion among [MnO2, WO3, and Nb / 2O5] the whole quantity, and it is desirable to contain especially Mn 0.02 to 0.5% of the weight by MnO2 conversion.
[0041] Moreover, it is thought by containing Mn, W, Nb, and Ta 0.01 to 3% of the weight by 2OMnO2, WO3, Nb 2O5, and Ta5 conversion that Q value becomes high for the oxygen defect included in the dielectric porcelain of this invention decreasing.
[0042] Specifically, the manufacture approach of the dielectric porcelain of this invention consists of following process (1a) - (8a).
[0043] As a start raw material, (1a) At least one sort of rare-earth-element oxide Ln2OX(s) of a high grade Each powder of (3<=x<=4 [however,]) and an aluminum oxide (aluminum 2O3) is used. Pure water is added after weighing capacity so that a request may become comparatively, and the ball mill which used the zirconia ball performs wet blending and grinding for 1 to 100 hours using the water whose cation metal concentration is

0.001 or less % of the weight until the mean diameter of this mixed raw material is set to 2.0 micrometers or less. Said rare-earth-element oxide Ln2OX (however, 3<=x<=4) and aluminum oxide (aluminum 2O3) use the raw material which contains Si and Fe 0.001 to 0.02% of the weight by SiO2 conversion by 2O0.001 - 0.02-% of the weight, and Fe3 conversion, respectively.

[0044] (2a) The temporary-quenching object which carries out temporary quenching at 1000-1300 degrees C after drying the obtained mixture for 1- 10 hours using the bowl which I will make a front face fix and will cook rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M is calcium and/or Sr), and Ti, and makes LnAlO (X+3)/2 (3<=x<=4) the main crystal phase is obtained (1a).

[0045] (3a) Similarly, using each powder of a calcium carbonate (CaCO3), a strontium carbonate (SrCO3), and titanium oxide (TiO2), add pure water after weighing capacity so that a request may become comparatively, and the ball mill which used the zirconia ball performs wet blending and grinding for 1 to 100 hours until the mean diameter of a mixed raw material is set to 2.0 micrometers or less. As for said water, cation metal concentration uses the water which is 0.001 or less % of the weight using the raw material in which a calcium carbonate (CaCO3), a strontium carbonate (SrCO3), and titanium oxide (TiO2) contain Si and Fe 0.001 to 0.02% of the weight by SiO2 conversion by 2O0.001 - 0.02-% of the weight, and Fe3 conversion, respectively.

[0046] (4a) The temporary-quenching object which carries out temporary quenching at 1000-1300 degrees C after drying the obtained mixture for 1- 10 hours using the bowl which I will make a front face fix and will cook rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M is calcium and/or Sr), and Ti, and makes MTiO3 (M is calcium and/or Sr) the main crystal phase is obtained (3a).

[0047] (5a) The temporary-quenching object which makes LnAlO (X+3)/2 obtained (3<=x<=4) the main crystal phase, and MTiO3 The temporary-quenching object made into the main crystal phase is mixed at a predetermined rate, and the ball mill which used the zirconia ball performs wet blending and grinding for 1 to 100 hours using the water whose cation metal concentration is 0.001 or less % of the weight until the mean diameter of this mixed raw material is set to 2.0 micrometers or less.

[0048] (6a) Furthermore, dehydrate after adding 3 - 10% of the weight of a binder, corn using a well-known approach, for example, the spray-drying method etc., after that, and obtain granulation powder.

[0049] (7a) The obtained granulation powder is fabricated in the configuration of arbitration by for example, the well-known die-press method, the cold isostatic press method, an extrusion-molding method, etc. (6a).

[0050] (8a) The acquired Plastic solid is calcinated at the temperature of 1400-1700 degrees C in the gas which does not contain Si substantially for 1 to 10 hours (7a). The obtained dielectric porcelain consists of a perovskite mold crystal which consists of the solid solution of LnAlO (X+3)/2 (3<=x<=4), and MTiO3 (M is calcium and/or Sr). Here, the gas which does not contain said Si substantially shows that Si concentration of said gas is 100 ppm or less.

[0051] It can be made to be able to contain in the range which mentioned above Si, Fe, and Zr which are contained on dielectric porcelain by the manufacture approach of this invention, respectively, and Q value can be improved by this. Furthermore, by the manufacture approach of the dielectric porcelain of this invention, Si can be made to be able to exist in the grain boundary and Q value can be raised further.

[0052] In the manufacture approach of the dielectric porcelain of this invention the content of Si, Fe, and Zr by SiO2 conversion, respectively 0.001 - 0.02 % of the weight, the rare earth elements (Ln) contained 0.001 to 0.8% of the weight by 2OFe3 conversion by 0.001 - 0.02-% of the weight, and ZrO2 conversion -- an oxide -- The process to which cation metal concentration carries out wet grinding of the raw material which consists of at least two or more sorts of aluminum oxide, M (M is calcium and/or Sr) oxide, and Ti oxide using 0.001 or less % of the weight of water is used for controlling Si, Zr, and Fe within the limits of this invention.

[0053] Moreover, in the manufacture approach of the dielectric porcelain of this invention, the process which carry out temporary quenching using the bowl which I will make fix and will cook rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M be calcium and/or Sr), and Ti be use for make it the impurity contain in a bowl like this during temporary quenching not mix in temporary-quenching powder. Generally, the thing which are used for temporary quenching, which consist of at least one or more sorts in a mullite, a zirconia, an alumina, a magnesia, etc. as a bowl like this and for which a bowl is used like this is performed. However, it becomes these causes by which said impurities, such as Si, Zr, Mg, etc. which are contained in a bowl like this, will mix in temporary-quenching powder, and Q value will be reduced if a bowl is

used as it is like this. In order to prevent the aforementioned mixing, rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M is calcium and/or Sr), and Ti are made to fix, and it is necessary to make it said impurity contained in a bowl like this not mix in temporary-quenching powder on the surface of a bowl like this. making rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M being calcium and/or Sr), and Ti fix on the surface of a bowl like this -- the oxide of rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti -- it is because it is difficult in one sort to make it fix stably chemically on the surface of a bowl like this inside.

[0054] Moreover, in the manufacture approach of the dielectric porcelain of this invention, the amount of Fe(s) is controllable by using the process which reduces Fe and Fe compound which are contained in the raw material fine particles before shaping. In order to reduce said Fe and Fe compound, the inside of a strong field is specifically passed for the raw material before shaping, and there is the approach of capturing Fe and Fe compound by the field, and removing. However, it is substantially difficult to carry out Fe and Fe compound to less than 0.001% of the weight by such approach.

[0055] Moreover, the process which calcinates Si in the gas which is not included substantially is used for controlling that the amount of Si contained on dielectric porcelain increases, when Si is spread to a calcinated object during baking. Moreover, thereby, the grain boundary can be made to contain Si. In order to calcinate in the gas which does not contain Si substantially, it is important to use the matter which does not contain Si in the heat insulator in the fixture for baking and a firing furnace etc.

[0056] Furthermore, the dielectric porcelain of this invention may add ZnO, NiO, SnO2, Co3O4, LiCO3, Rb2CO3, Sc2O3, V2O5, CuO, MgCO3 and Cr 2O3, B-2s Sb [O3 GeO2, and] 2O5, and Ga2O3 grade further. Although these are based also on the addition component, they can be added at a rate below a total of five weight sections to the principal component 100 weight section for the purpose of epsilonr, rationalization of the value of temperature coefficient tauf of resonance frequency, etc.

[0057] Moreover, the dielectric porcelain of this invention is used especially most suitably as dielectric porcelain of a dielectric resonator. The schematic diagram of the dielectric resonator of a TE-mode mold was shown in drawing 1 . The dielectric resonator of drawing 1 forms an input terminal 2 and an output terminal 3 in the both sides which metal casing 1 wall faces, arranges the dielectric porcelain 4 which consists of the above-mentioned dielectric porcelain among these input/output terminals 2 and 3, and is constituted. As for such a TE-mode mold dielectric resonator, microwave is inputted from an input terminal 2, and microwave is shut up by reflection of the boundary of the dielectric porcelain 4 and free space in the dielectric porcelain 4, and causes resonance on a specific frequency by it. This signal carries out electromagnetic-field association with an output terminal 3, and is outputted.

[0058] Moreover, although not illustrated, of course, the dielectric porcelain of this invention may be applied to the coaxial-type resonator using the TEM mode, a strip line resonator, the dielectric porcelain resonator of the TM mode, and other resonators. Furthermore, a dielectric resonator can be constituted even if it forms an input terminal 2 and an output terminal 3 in the dielectric porcelain 4 directly.

[0059] Although the above-mentioned dielectric porcelain 4 is the resonance medium of the predetermined configuration which consists of dielectric porcelain of this invention, the configuration should just be a rectangular parallelepiped, a cube, a plate, a disk, a cylinder, a multiple column, and other solid configurations that can be resonated. Moreover, the frequency of the RF signal inputted is 800MHz - about 500GHz, and 2GHz - its about 80GHz is desirable practically as resonance frequency.

[0060] In addition, this invention is not limited to the above-mentioned operation gestalt, and modification various in the range which does not change the summary of this invention does not interfere at all.

[0061]

[Example] As shown in one or less example - (1b) (5b), the sample of this invention was produced.

[0062] As a start raw material, Si, Zr, and Fe by SiO2 conversion, respectively (1b) 0.001 - 0.02 % of the weight, Rare-earth-element oxide Ln2OX contained 0.001 to 0.02% of the weight by ZrO2 conversion by 2O0.001 - 0.8-% of the weight, and Fe3 conversion And each powder of an aluminum oxide (aluminum 2O3) is used. (However, 3<=x<=4) Pure water was added after weighing capacity so that a request might become comparatively, and the ball mill which used the zirconia ball performed wet blending and grinding for 1 to 100 hours using the water whose cation metal concentration is 0.001 or less % of the weight until the mean diameter

of this mixed raw material was set to 2.0 micrometers or less.
[0063] The temporary-quenching object which carries out temporary quenching to a rare earth element Ln at 1100-1250 degrees C for 3 hours after drying the mixture obtained by (2b) and (1b) using ****** made from a mullite which made the inside front face of a bowl fix the multiple oxide of aluminum chemically like this, and makes LnAlO (X+3)/2 (3<=x<=4) the main crystal phase was obtained.
[0064] Si, Zr, and Fe by SiO2 conversion, respectively (3b) 0.001 - 0.02 % of the weight, Using each powder of the calcium carbonate (CaCO3) contained 0.001 to 0.02% of the weight, a strontium carbonate (SrCO3), and titanium oxide (TiO2) so that a request may become comparatively by ZrO2 conversion by 2O0.001 - 0.8-% of the weight, and Fe3 conversion After weighing capacity, Pure water was added, and the ball mill which used the zirconia ball performed wet blending and grinding for 30 hours using the water whose cation metal concentration is 0.001 or less % of the weight until the mean diameter of this mixed raw material was set to 2.0 micrometers or less.
[0065] (4b) The temporary-quenching object which carries out temporary quenching at 1100-1250 degrees C after drying the obtained mixture for 3 hours using the bowl which I will make the inside front face of a bowl fix chemically like this, and will cook the multiple oxide containing calcium, Sr, and Ti, and makes MTiO3 (M is calcium and/or Sr) the main crystal phase was obtained (3b).
[0066] (5b) The temporary-quenching object which makes LnAlO (X+3)/2 obtained (3<=x<=4) the main crystal phase, MTiO3 The temporary-quenching object made into the main crystal phase and 2OMnO2, WO3, Nb 2O5, and Ta5 conversion are mixed at a rate shown in Table 1. The ball mill which used the zirconia ball performed wet blending and grinding using the water whose cation metal concentration is 0.001 or less % of the weight for 30 hours until the mean diameter of this mixed raw material was set to 2.0 micrometers or less.
[0067] (6b) After adding 3 - 10% of the weight of the binder and dehydrating furthermore, it corned by the spray-drying method and granulation powder was obtained.
[0068] (7b) The obtained granulation powder was fabricated in the diameter of 20mm, and the configuration with a thickness of 11mm by the die-press method (6b).
[0069] (8b) The acquired Plastic solid was calcinated at the temperature of 1500-1650 degrees C for 20 hours in the gas which does not contain Si substantially (7b). The obtained dielectric porcelain consisted of the perovskite mold crystal which consists of the solid solution of LnAlO (X+3)/2 (3<=x<=4), and MTiO3 (M is calcium and/or Sr). Moreover, Si, Fe, and the amount of Zr which are contained in the obtained dielectric porcelain were measured by ICP emission spectrochemical analysis, and it converted into SiO2, Fe 2O3, and ZrO2, respectively.
[0070] And flat-surface polish of the disk section (principal plane) of the obtained sintered compact was carried out, and it cleaned ultrasonically in the acetone, and after drying at 150 degrees C for 1 hour, temperature coefficient tauf of specific-inductive-capacity epsilonr, Q value, and resonance frequency was measured by 3.5-5.5GHz of test frequencies by the cylinder resonator method. Q value was converted into the Q value in 1GHz from the relation of x(Q value) (test frequency f) = (fixed) generally materialized in dielectric ceramics for microwave. The temperature coefficient of resonance frequency computed temperature coefficient [of 25-85 degrees C] tauf on the basis of the resonance frequency at the time of 25 degrees C.
[0071] Moreover, it is Technoorg about a sintered compact. It was processed using the ion SHININGU equipment made from Linda, and checked whether Si would exist in the grain boundary using transmission electron microscope JEM2010F of JEOL, and the EDS analysis apparatus VoyagerIV of NoranInstruments.
[0072] These results are shown in Tables 1 and 2. In addition, in Table 1, the ratio of a rare earth element expresses that the sample whose ratio of the mole ratio of Y and La being 0.2:0.8, for example, rare earth elements, of the sample of 0.2Y and 0.8La is La is a sample which used La for rare earth. Moreover, the sample by which the sample which put O mark in Table 2 put the sample by which Si was observed in the grain boundary, and x mark shows the sample by which Si was not observed in the grain boundary.
[0073] Sample No.1-48 within the limits of this invention had Q value as high as 46000 or more in case Q value when specific-inductive-capacity epsilonr converts into 30-48, and 1GHz is [especially epsilonr] 40 or more 43000 or more, and the dielectric characteristics which f excelled less than in **tau30 (ppm/degree C) were obtained so that clearly from Tables 1 and 2.
[0074] On the other hand, the content of Si, Fe, and Zr by SiO2 conversion, respectively 0.001 - 0.02 % of the

weight, the rare earth elements (Ln) contained 0.001 to 0.8% of the weight by 2OFe3 conversion by 0.001 - 0.02-% of the weight, and ZrO2 conversion -- an oxide -- The process which carries out wet grinding of the raw material which consists of at least two or more sorts of aluminum oxide, M (M is calcium and/or Sr) oxide, and Ti oxide using water with more cation metal concentration than 0.001 % of the weight, The process which carries out temporary quenching of rare-earth-element oxide Ln2OX (however, 3<=x<=4) and the preferential grinding powder of an aluminum oxide (aluminum 2O3) using mullite ******, The process which carries out temporary quenching of the preferential grinding powder of a calcium carbonate (CaCO3), a strontium carbonate (SrCO3), and titanium oxide (TiO2) using zirconia ******, Including the process calcinated in the gas containing Si, the dielectric porcelain (sample No.49-56) of this invention produced by the manufacture approach of having not reduced Fe and Fe compound which are contained in the raw material fine particles before shaping out of range has low epsilonr, or Q value was low and the absolute value of tauf was large.
[0075]
[Table 1]

試料 No.	希土類元素の比率	CaOとSrOとの比率		Ln_2O_X	Al_2O_3	MO =CaO+SrO	TiO_2	$\frac{(b+d)}{(a+c)}$	MnO_2 (重量%)	WO_3 (重量%)	Nb_2O_5 (重量%)
		CaO	SrO	a	b	c	d				
1	0.2Y·08La	0.00	1.00	0.0800	0.0800	0.4400	0.4000	0.923	0.01	0.00	0.00
2	0.2Sm·0.8Nd	0.45	0.55	0.1240	0.1300	0.3730	0.3730	1.012	1.00	0.00	0.00
3	0.3La·0.7Sm	0.80	0.20	0.2140	0.2140	0.2860	0.2860	1.000	0.04	0.00	0.00
4	Nd	0.60	0.40	0.1250	0.1260	0.3300	0.4180	1.198	0.40	0.10	0.00
5	0.1La·0.7Nd	0.90	0.10	0.1250	0.1250	0.4170	0.3330	0.845	0.30	0.00	0.00
6	0.3La·0.7Nd	0.20	0.80	0.2090	0.2050	0.2860	0.3000	1.020	0.00	0.00	0.00
7	0.1Ce·0.9Sm	0.40	0.60	0.1539	0.1661	0.3300	0.3500	1.067	0.00	0.00	0.01
8	0.1Ce·0.9Nd	0.60	0.40	0.0560	0.0560	0.4580	0.4300	0.946	0.00	0.00	0.04
9	0.2Nd·0.8La	0.10	0.90	0.0600	0.0610	0.4954	0.3836	0.801	0.00	0.00	0.00
10	0.1Pr·0.9Nd	0.50	0.50	0.0941	0.1009	0.4600	0.3450	0.805	0.00	0.01	0.00
11	0.5Sm·0.5Nd	0.70	0.30	0.0770	0.0770	0.4300	0.4160	0.972	0.00	0.05	0.00
12	Sm	0.80	0.20	0.0700	0.0560	0.4240	0.4500	1.024	0.00	0.07	0.00
13	0.1Sm·0.9Nd	0.80	0.20	0.1320	0.1600	0.3270	0.3810	1.179	0.00	1.00	0.00
14	0.6Sm·0.4Nd	0.40	0.60	0.1071	0.1090	0.3539	0.4300	1.169	0.00	1.20	0.00
15	Eu	0.80	0.20	0.0800	0.0600	0.5000	0.3800	0.786	0.00	0.00	0.00
16	0.9Eu·0.1Nd	0.40	0.60	0.1400	0.1750	0.3350	0.3500	1.105	0.00	0.01	0.50
17	Gd	0.20	0.80	0.0600	0.0600	0.4105	0.4695	1.125	0.00	0.03	0.00
18	0.1Gd·0.9Nd	0.80	0.20	0.0780	0.0780	0.4220	0.4220	1.000	0.00	0.08	0.00
19	Dy	0.30	0.70	0.1166	0.1166	0.4267	0.3401	0.841	0.00	1.00	1.00
20	0.1Dy·0.9Nd	0.45	0.55	0.1098	0.1098	0.3902	0.3902	1.000	0.03	0.02	0.00
21	0.8Dy·0.2Nd	1.00	0.00	0.0790	0.0790	0.4610	0.3810	0.852	0.03	0.00	0.00
22	0.1Sm·0.9La	0.45	0.55	0.0881	0.0881	0.4119	0.4119	1.000	0.09	0.00	0.00
23	0.2Nd·0.8La	0.45	0.55	0.1072	0.1072	0.4376	0.3480	0.836	1.00	0.00	0.00
24	0.1Gd·0.9Eu	0.05	0.95	0.0884	0.0884	0.4100	0.4132	1.006	0.02	1.30	0.00
25	0.2Dy·0.8Eu	0.55	0.45	0.1700	0.1760	0.3270	0.3270	1.012	0.00	0.00	0.00
26	0.9Nd·0.1La	0.15	0.85	0.2130	0.2120	0.3440	0.2310	0.795	0.07	0.05	0.00
27	La	0.15	0.85	0.1000	0.1000	0.4000	0.4000	1.000	0.06	0.09	0.00
28	0.9Nd·0.1La	0.35	0.65	0.1200	0.1220	0.3750	0.3830	1.020	0.01	0.00	0.00
29	La	0	1	0.1610	0.1620	0.3390	0.3380	1.000	0.00	0.00	0.00
30	La	0	1	0.1305	0.1599	0.3546	0.3550	1.061	0.00	0.05	0.00
31	La	0	1	0.2101	0.1691	0.3456	0.2752	0.800	0.50	0.50	0.00
32	La	0	1	0.1386	0.1441	0.3765	0.3408	0.941	0.25	0.25	0.00
33	La	0	1	0.1710	0.2090	0.3458	0.2742	0.935	0.10	0.10	0.00
34	La	0	1	0.1058	0.1063	0.3930	0.3949	1.005	0.05	0.05	0.00
35	La	0	1	0.1798	0.1446	0.3040	0.3716	1.067	0.01	0.00	0.01
36	La	0	1	0.1448	0.1452	0.3959	0.3141	0.849	0.05	0.00	0.05
37	La	0.1	0.9	0.1168	0.1261	0.4090	0.3481	0.902	1.00	0.00	0.00
38	La	0	1	0.1206	0.1210	0.3790	0.3794	1.002	0.01	0.02	0.00
39	La	0	1	0.1279	0.1387	0.3596	0.3738	1.051	0.40	0.00	0.10
40	La	0	1	0.2166	0.1636	0.3039	0.3159	0.921	0.30	0.00	0.00
41	La	0.85	0.15	0.1404	0.1410	0.3592	0.3594	1.002	0.20	0.00	0.00
42	La	1	0	0.1705	0.2088	0.3162	0.3045	1.055	0.00	0.00	0.00
43	La	1	0	0.1071	0.1058	0.3506	0.4365	1.185	0.00	0.99	0.02
44	La	1	0	0.1127	0.1371	0.4123	0.3379	0.906	0.05	0.05	0.00
45	La	1	0	0.1510	0.1143	0.4185	0.3162	0.756	0.03	0.62	0.00
46	La	1	0	0.1329	0.1653	0.3120	0.3898	1.248	1.00	0.00	1.00
47	La	1	0	0.1899	0.1897	0.3102	0.3102	1.000	0.00	0.03	0.00
48	La	1	0	0.1301	0.1116	0.3981	0.3602	0.893	0.00	0.00	0.01
*49	Y	0.15	0.85	0.0800	0.0800	0.4200	0.4200	1.000	0.00	0.00	0.00
*50	0.7Yb·0.3Ce	0.00	1.00	0.2000	0.2100	0.2900	0.3000	1.041	0.00	0.00	0.00
*51	Nd	0.05	0.95	0.0660	0.0600	0.4850	0.3990	0.815	0.00	0.00	0.00
*52	0.2Dy·0.8Gd	0.50	0.50	0.2100	0.2000	0.2900	0.3000	1.000	0.00	0.00	0.00
*53	Ce	0.80	0.20	0.0750	0.0555	0.4900	0.3795	0.770	0.00	0.00	0.00
*54	0.7Pr·0.3Eu	1.00	0.00	0.1130	0.1260	0.4000	0.3610	0.949	0.00	0.00	0.00
*55	0.3Er·0.7La	0.90	0.10	0.0675	0.0675	0.3850	0.4800	1.210	0.00	0.00	0.00
*56	0.8Nd·0.2Y	1.00	0.00	0.1600	0.0900	0.3720	0.3780	0.880	0.00	0.00	0.00

*を付けた試料番号は本発明の請求範囲外のものである。

[0076]

[Table 2]

試料 No.	Ta_2O_5 (重量%)	MnO_2 + WO_3 + Nb_2O_5 + Ta_2O_5 (重量%)	SiO_2 (重量%)	Fe_2O_3 (重量%)	ZrO_2 (重量%)	結晶粒界におけるSiの存在	誘電特性 εr	Q値	τf ppm/℃
1	0.01	0.02	0.015	0.018	0.009	×	45.9	48000	24.4
2	0.00	1.00	0.004	0.009	0.275	×	35.6	51000	-24.8
3	0.00	0.04	0.007	0.01	0.124	○	32.0	54000	1.9
4	0.00	0.50	0.007	0.002	0.394	×	40.7	48000	-15.3
5	0.00	0.30	0.01	0.001	0.182	○	39.0	53000	-12.9
6	0.01	0.01	0.008	0.007	0.042	○	33.2	62000	-24.5
7	0.02	0.03	0.006	0.007	0.352	×	39.7	47000	-0.5
8	0.00	0.04	0.003	0.004	0.064	×	43.9	49000	11.0
9	0.00	0.00	0.013	0.013	0.041	○	39.8	47000	26.8
10	0.01	0.02	0.002	0.003	0.159	×	38.3	47000	26.3
11	0.00	0.05	0.017	0.015	0.047	×	47.5	50000	26.9
12	0.00	0.07	0.005	0.006	0.084	×	48.2	52000	19.6
13	0.00	1.00	0.003	0.005	0.123	○	45.9	55000	-4.2
14	0.00	1.20	0.019	0.018	0.005	○	39.6	43000	10.3
15	0.00	0.00	0.018	0.02	0.059	×	36.8	43000	15.3
16	0.00	0.51	0.006	0.009	0.029	○	36.3	49000	-13.2
17	0.05	0.08	0.018	0.018	0.008	×	35.3	43000	17.7
18	1.50	1.58	0.005	0.007	0.032	○	43.2	57000	19.5
19	0.00	2.00	0.001	0.004	0.347	○	41.8	62000	1.0
20	0.50	0.55	0.007	0.002	0.268	○	40.3	59000	1.9
21	0.00	0.03	0.003	0.005	0.277	○	34.8	55000	2.5
22	0.20	0.29	0.002	0.006	0.242	○	43.9	50000	25.3
23	0.01	1.01	0.009	0.005	0.349	○	43.1	55000	3.7
24	0.00	1.32	0.018	0.012	0.01	×	40.0	46000	19.6
25	0.00	0.00	0.02	0.019	0.077	○	39.5	45000	-2.3
26	0.00	0.12	0.005	0.008	0.085	○	32.7	51000	27.3
27	0.70	0.85	0.016	0.016	0.011	○	44.8	49000	1.0
28	0.00	0.01	0.008	0.003	0.084	○	44.7	50000	-3.2
29	0.01	0.01	0.007	0.005	0.173	○	37.9	49000	-10.0
30	0.00	0.05	0.006	0.003	0.227	○	39.3	51000	5.6
31	0.00	1.00	0.003	0.008	0.364	○	32.6	57000	-24.8
32	0.00	0.50	0.004	0.002	0.026	×	39.0	60000	3.2
33	0.00	0.20	0.01	0.001	0.173	×	34.8	62000	-19.9
34	0.00	0.10	0.001	0.009	0.073	×	46.6	52000	27.6
35	0.00	0.02	0.009	0.001	0.318	×	38.9	59000	-2.9
36	0.00	0.10	0.001	0.002	0.095	×	34.0	47000	-6.3
37	0.01	1.01	0.003	0.006	0.182	×	38.7	58000	20.6
38	0.00	0.03	0.004	0.008	0.314	○	45.9	61000	16.7
39	0.00	0.50	0.004	0.005	0.011	○	44.7	52000	11.9
40	0.10	0.40	0.014	0.018	0.045	○	37.0	51000	-18.1
41	0.00	0.20	0.007	0.008	0.015	×	40.3	71000	2.0
42	0.01	0.01	0.02	0.02	0.800	○	31.8	43000	-15.5
43	0.01	1.02	0.008	0.004	0.053	×	42.7	49000	27.6
44	2.90	3.00	0.005	0.009	0.253	×	35.9	51000	17.7
45	0.00	0.55	0.008	0.002	0.052	×	33.6	62000	3.9
46	0.00	2.00	0.009	0.002	0.019	×	32.8	52000	2.5
47	0.00	0.03	0.002	0.003	0.063	○	30.4	82000	-23.2
48	0.00	0.01	0.017	0.02	0.042	○	32.8	43000	11.8
*49	0.00	0.00	0.034	0.042	1.53	×	35.7	15000	33.4
*50	0.00	0.00	0.045	0.025	1.73	×	39.9	9000	-37.0
*51	0.00	0.00	0.052	0.053	1.01	×	28.5	14000	-33.6
*52	0.00	0.00	0.025	0.062	0.96	×	38.2	1E+05	-40.0
*53	0.00	0.00	0.032	0.073	1.34	×	33.0	11000	41.5
*54	0.00	0.00	0.053	0.035	2.72	×	31.5	10000	-36.1
*55	0.00	0.00	0.062	0.037	1.93	×	34.1	16000	38.7
*56	0.00	0.00	0.036	0.053	1.33	×	37.2	15000	7.3

*を付けた試料番号は本発明の請求範囲外のものである。

[0077]

[Effect of the Invention] By consisting of the polycrystalline substance which uses as a principal component the oxide which contains rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti at least as a metallic element in this invention, and carrying out specified quantity content of Si, Fe, and the Zr, it sets to a RF field and is high specific-inductive-capacity epsilonr. And high Q value can be obtained. Thereby, it is applicable to the charge of resonator material used in microwave or a millimeter wave field, the dielectric

substrate ingredient for Media Interface Connector, a dielectric waveguide, a dielectric antenna, other various electronic parts, etc.

[Translation done.]

CLAIMS

[Claim(s)]

[Claim 1] Dielectric porcelain to which it consists of rare earth elements (Ln) and the polycrystalline substance which uses the oxide containing aluminum, M (M is calcium and/or Sr), and Ti as a principal component, and the content of Si, Fe, and Zr is characterized by being 0.001 - 0.8 % of the weight by Fe2O3 conversion 0.001 to 0.02% of the weight by SiO2 conversion at least as a metallic element at 0.001 - 0.02-% of the weight, and ZrO2 conversion, respectively.

[Claim 2] Dielectric porcelain according to claim 1 characterized by Si existing in the grain boundary.

[Claim 3] Rare earth elements (Ln), and aluminum, M (M is calcium and/or Sr) and Ti are contained at least as a metallic element, and it is an empirical formula aLn2 OX-bAl2O3 and cMO-dTiO2 (however, 3<=x<=4) Dielectric porcelain given in either of claims 1 and 2 to which a, b, c, and d are characterized by satisfying 0.056 <=a<=0.2140.056 <=b<=0.2140.286 <=c<=0.5000.230<d<0.470 a+b+c+d=1 when expressed.

[Claim 4] Dielectric porcelain according to claim 1 to 3 characterized by containing at least one sort in Mn, W, Nb, and Ta a total of 0.01 to 3% of the weight as a metallic element by 2OMnO2, WO3, Nb 2O5, and Ta5 conversion.

[Claim 5] The manufacture approach of the dielectric porcelain characterized by providing the following Si -- Fe -- and -- Zr -- a content -- respectively -- SiO -- two -- conversion -- 0.001 - 0.02 -- % of the weight -- Fe -- two -- O -- three -- conversion -- 0.001 - 0.02 -- % of the weight -- and -- ZrO -- two -- conversion -- 0.001 - 0.8 -- % of the weight -- containing -- rare earth elements -- (-- Ln --) -- an oxide -- aluminum -- an oxide -- M (M is calcium and/or Sr) -- an oxide -- and -- Ti -- an oxide -- inside -- at least -- two -- a sort -- more than -- from -- becoming -- a raw material -- cation metal concentration -- 0.001 or less % of the weight of water -- using -- wet grinding -- carrying out -- a process The process which carries out temporary quenching using the bowl which I will make fix and will cook rare earth elements (Ln) and the oxide containing at least two or more sorts in aluminum, M (M is calcium and/or Sr), and Ti The process which reduces Fe and Fe compound which are contained in the raw material fine particles before shaping The process which calcinates Si in the gas which is not included substantially

[Claim 6] The dielectric resonator characterized by coming to arrange dielectric porcelain according to claim 1 to 4, and making it operate by electromagnetic-field association between the input/output terminals of a pair.

[Translation done.]